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Article

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Abstract

The authors test predictions from climato-economic theories of culture that climate and wealth interact in their influence on psychological processes. Demanding climates (defined as colder than temperate and hotter than temperate climates) create potential threats for humans. If these demands can be met by available economic resources, individuals experience challenging opportunities for self-expression and personal growth and consequently will report lowest levels of ill-being. If threatening climatic demands cannot be met by resources, resulting levels of reported ill-being will be highest. These predictions are confirmed in nation-level means of health complaints, burnout, anxiety, and depression across 58 societies. Climate, wealth, and their interaction together account for 35% of the variation in overall subjective ill-being, even when controlling for known predictors of subjective well-being. Further investigations of the process suggest that cultural individualism does not mediate these effects, but subjective well-being may function as a mediator of the impact of ecological variables on ill-being.

Keywords

climato-economic theory, subjective well-being, demanding climate, individualism, culture, wealth

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There is little doubt that weather affects psychic processes such as mood and somatic processes such as physical health. We are feeling up if the sun is shining, and we are more likely to get the flu in cold weather. However, what is not known is whether climate, defined as the average weather, affects the psychological well-being of the average citizen. Given the current concern about changing climate, it is timely to explore how climatic conditions affect indicators of psychological ill-being. More broadly, there currently is great interest among psychologists, sociologists, economists, and policy makers about what makes a country's inhabitants happier and healthier than others. We are drawing on a recently developed climato-economic theory of culture (Van de Vliert, 2007, 2009) to examine whether and how the interaction between climate and wealth influences clinical indicators of general health complaints, burnout, anxiety, and depression (ill-being).

What Makes National Populations Happy?

This question about origins of national happiness or subjective well-being (SWB) has attracted a significant amount of attention across disciplines (for an overview, see Diener & Suh, 2000). Correlational evidence suggests that increased wealth is associated with greater well-being (Diener, Diener, & Diener, 1995; Diener, Harter, & Arora, 2010; Fischer & Boer, 2011; Rentfrow, Mellander, & Florida, 2009; Schyns, 1998; Stevenson & Wolfers, 2008). Wealth and associated society-level indicators including democratic institutions, education, liberal values, and longevity (Inglehart & Welzel, 2005) implicate variables that human kind has created to enhance happiness and that remain largely under human control. However, could it be that the liveability of the environment itself has some remote and unnoticed impact on levels of well-being? Recent insights and research indeed suggest that this picture of predictors of well-being has to be contextualized because climate (in particular demanding climate) in the background tends to secretly contribute to the above pattern of associations in the foreground.

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Climato-Economic Theory

The central tenet of the climato-economic theory of culture (Van de Vliert, 2007, 2009) is that climate-based demands and wealth-based resources jointly affect human functioning. Richer countries with harsher than temperate winters or summers represent habitats that challenge the inhabitants' creativity and skills to cope satisfactorily with climatic liveability problems. Poorer countries in harsher than temperate climates, by contrast, threaten the inhabitants' satisfaction of basic needs for thermal comfort, nutrition, and health.

In colder than temperate and hotter than temperate climates it is persistently more difficult to maintain a core body temperature of approximately 37°C, to create protective devices including clothing, shelter structures, and heating or cooling systems, to transform flora and fauna into life-sustaining food, and to safeguard health. Self-evidently, these threats and challenges of climatic demands cannot be properly understood without taking into account complementary and compensatory money resources available to buy necessities of life including warmth and coolness, food and drink, cure and care. Greater national wealth also creates better markets for trading climate-related goods and services, higher education, and more personal, social, and political freedom (United Nations Development Programme [UNDP], 2007), all of which also increase people's competence to successfully cope with climatic cold and heat.

In richer countries with harsher winters or summers inhabitants have abundant resources to counter these cyclical climatic challenges. Because all climatic demands can be adequately met and thereby provide opportunities for growth and stimulation, levels of ill-being are expected to be among the lowest on earth in these affluent countries. By contrast, in poorer countries with more threatening winters or summers inhabitants are at the mercy of climate. Income, facilities, and autonomy fall short of meeting the demands posed by the climate. Therefore, we expected levels of ill-being in these harsh–poor habitats to be among the highest on earth. Finally, temperate climates offer pleasant temperatures, abundant food resources owing to the rich flora and fauna, and negligible risks of unhealthy weather conditions. This type of climate evokes fewer challenges and threats. In consequence, wealth-based resources are thought to make less of a difference for the inhabitants' experience of ill-being. Both rich and poor populations in temperate climates will have lower levels of ill-feeling than poor populations in harsher climates, albeit not as low as rich societies in harsher climates. Van de Vliert (2009) found preliminary support for the predicted interaction when examining suicide rates and single-item reports of happiness and health.

Our aim is to investigate the interplay between climate and wealth in their effect on clinically validated psychological indicators that cover specific bodily and psychic symptoms associated with ill-being. We report new analyses of standardized measures of health complaints, burnout, depression, and anxiety.

Hypothesis 1: Climatic demands and national wealth will interact in their prediction and explanation of ill-being. Ill-being will be highest in societies with strong climatic demands and low national wealth, intermediate in temperate climates independent of wealth, and lowest in societies with strong climatic demands and high national wealth.

Examining Mediating Process Models

The inclusion of ill-being can also help to illuminate the process through which climato-economic processes are operating. Is overall positive affect driving evaluations of specific mental health problems, or are negative experiences in specific areas affecting the overall well-being of individuals? This is a question that has interested philosophers and social scientists for centuries. Diener (1984) proposed two different hypotheses about the relation between general and specific measures of well-being. Bottom-up approaches maintain that overall happiness or well-being is the sum of the individual experiences, akin to Lockean empiricism in which all ideas are derived from external or internal experiences by the individual (Locke, 1690/2004). This would mean that absence of negative experiences (ill-being) and the presence of many small positive experiences would lead to overall well-being. In contrast, top-down approaches specify that there is a general propensity to feel happy and this general feeling then influences the specific states at any given moment. The general feeling of overall well-being influences and shapes immediate experiences in specific contexts, that is, a person sleeps well and feels alert and emotionally stable because he or she is happy overall, not vice versa (as first discussed by Democritus; see Diener, 1984).

The psychologically extremely relevant bottom-up and top-down approaches have been studied at the individual level, with current evidence suggesting that the type of relationship is complex. Some studies show support for top-down models (e.g., Leonardi, Spazzafumo, & Marcellini, 2005; Nakazato, Schimmack, & Oishi, 2010), whereas others suggest that the influence may be bidirectional and dependent on the specific domain (e.g., Lance, Mallard, & Michalos, 1995; Scherpenzeel & Saris, 1996). To the best of our knowledge, the current study is the first to compare the predictive power of these models at the societal level.

As represented in Figure 1, top-down influences would suggest that climate and wealth interact in affecting general feelings of well-being directly and that this overall positive (or negative) evaluation of life then filters down to specific experiences and domains. In contrast, bottom-up processes would indicate that climatic demands coupled with poor resources lead to negative experiences, which then influence

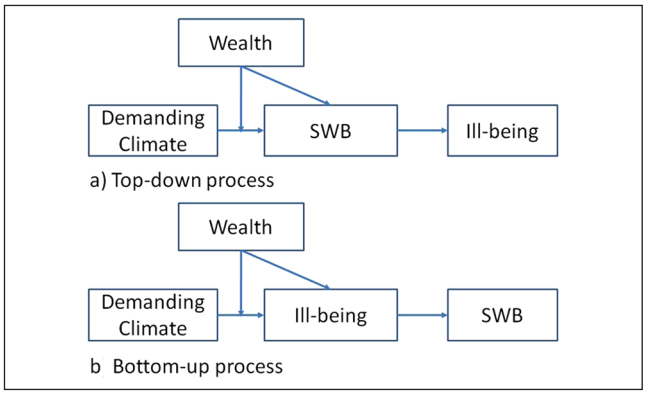

Figure 1. Top-down versus bottom-up process models linking climato-economic variables to subjective well-being (SWB) and ill-being

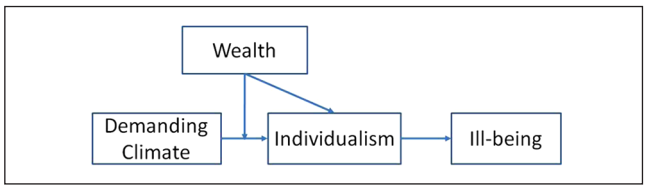

Figure 2. Proposed mediation model of individualism linking climato-economic variables to individualism and ill-being

overall levels of well-being. Therefore, comparing these two alternative process models can contribute to new insights to long-standing debates in philosophy and psychology at the societal level.

A second process model of interest, represented in Figure 2, involves individualism. We argue that climate and wealth are the background variables that influence psychological processes. Given the broad nature of individualism as a central feature of the organization of social life in modern societies, we could speculate that climate and wealth provide the ecological context, in which individuals are socialized to engage in more interdependent collectivistic or more independent individualistic social roles. These roles and the opportunities that these roles afford individuals then have some influence on the experience of mental health, leading to greater or lower ill-being. The greater autonomy afforded to individuals in individualistic societies should lead to greater well-being and an absence of ill-being.

This reasoning is in line with findings demonstrating that individualism is a relatively consistent and strong predictor of SWB (e.g., Diener et al., 1995; Fischer & Boer, 2011). Moreover, individualism itself is linked to both climate and wealth. In demanding climates with few resources people have to rely on their immediate in-groups to make ends meet and ensure survival. These ecological pressures motivate individuals to emphasize one's in-group and favoring the in-group over the out-group, curbing one's self-expression and instead emphasizing group security and survival (Van de Vliert, 2009, 2011). Hence, we propose that climate and wealth have an effect on ill-being through individualism. We tested whether broad cultural dimensions of individualism versus collectivism can explain the presumed joint effects of climate and wealth on ill-being.

In addition to these process models that control and explain alternative processes, we further tested the robustness of the predicted interaction effect of demanding climate and local wealth, controlling for known population-level correlates of SWB. First, income inequality decreases physical health (Wilkinson & Pickett, 2009; but see Berg & Veenhoven, 2010, for evidence to the contrary), which in turn may decrease mental health. Second, democracy indicators have also been implicated in investigations because of their links with increased psychological well-being (Diener et al., 1995; Inglehart & Welzel, 2005). Third, the prevalence of disease pathogens (Murray & Schaller, 2010) is likely to influence SWB. The more infectious diseases are common within a region, the more they will undermine the average well-being of national populations in that region. Here, we test whether pathogen prevalence is able to wipe out the climato-economic interaction effect. We present a series of tests to examine the robustness and added value of our proposed model.

Method

Dependent Variable

We used available indicators of general health complaints (Goldberg, 1972), burnout (Maslach & Jackson, 1981), state and trait anxiety (Spielberger, Gorsuch, & Lushene, 1970), and depression (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). These instruments were developed and validated in clinical research and yield standardized scores. More importantly, researchers have tested various nonclinical populations across a large number of counties and countries and published the results in peer-reviewed journals. These data were meta-analytically compiled by Fischer and Boer (2011) and Van Hemert, Van de Vijver, and Poortinga (2002), averaging published scores of the General Health Questionnaire (Goldberg, 1972), the Maslach Burnout Inventory (Maslach & Jackson, 1981), the Spielberger State-Trait Inventory (Spielberger et al., 1970), and the Beck Depression Inventory (Beck et al., 1961) in nonclinical adult populations. These nation-level means show appropriate reliability and validity and relate in a meaningful way to other nation-level variables (Fischer & Boer, 2011; Van Hemert et al., 2002). We averaged these previously aggregated population-level scores into a general indicator of national ill-being.

Population-level data for general health were available for 48 countries, for burnout for 25 countries, state anxiety for 27 countries, and trait anxiety for 24 countries (all from Fischer & Boer, 2011). Depression scores for 27 societies were available from Van Hemert et al. (2002). A principal

Table 1. Correlations Among Population-Level Variables

	1	2	3	4	5	6	7	8
1. Ill-being	—							
2. Climatic demands	.05	—						
3. National wealth	−.34*	.51**	—					
4. Individualism	−.49*	.48**	.77**	—				
5. Income inequality	.27	−.44**	−.29	−.32*	—			
6. Democracy	−.33*	.45**	.52**	.74**	−.39**	—		
7. Disease prevalence	.32*	−.68**	−.71**	−.70**	.38**	−.51**	—	
8. Subjective well-being	−.60**	.03	.59**	.67**	−.02	.37**	−.38**	—

N = 58 national populations.
*$p < .05$. **$p < .01$.

component analysis on normalized data with both listwise and pairwise deletion of missing data showed two factors with eigenvalues larger than 1. To determine the number of factors, parallel analysis was run (Hayton, Allen, & Scarpello, 2004), as it is a more robust method for deciding how many components should be extracted. Both the 95% and 99% percentile values suggested extraction of a single factor. This factor explained 50.55% of the variance. The internal consistency of this combined index was .67 (Cronbach's alpha), which makes the index neither too heterogeneous ($\alpha < .60$) nor too homogeneous ($\alpha > .80$) to yield problematic research conclusions (see Van de Vliert, 2009, pp. 122-124). Deleting the trait anxiety component increased internal consistency to .81. Results after removing trait anxiety are similar to those reported below (unless noted otherwise). Averaging normalized scores, data from 58 societies were available for relating them to other population-level variables that served as predictors and as factors to be controlled for in supplementary analyses (see Tables 1 and 2).

Predictor Variables

Climatic demands is expressed as the sum of the deviations from 22°C (approximately 72°F) for the lowest and highest temperatures in the coldest month and the lowest and highest temperatures in the hottest month (for details and country indices, see Van de Vliert, 2009). In our sample, the sum of these four absolute deviations ranged from 28 in Samoa to 105 in Canada ($M = 64$, $SD = 21$). One potential problem with a country-level approach is temperature variations in countries spanning multiple latitudes. Previous research (Van de Vliert, 2009, 2011) has demonstrated that excluding or adjusting for error-inducing temperature variations within countries strengthens climate effects. Therefore, we do not adjust for multiple latitudes, and the results can be interpreted as conservative estimates of climate effects.

Wealth was measured by the gross national income expressed in product purchase parity per head from 1980, 1985, 1990, 1995, 2000, and 2005 (UNDP, 2007). Missing data (e.g., for Taiwan) was imputed using most recently available data from the CIA World Factbook (www.cia.gov, last retrieved October 25, 2010). These indicators loaded on a single factor in a principal component analysis (explaining 97.86% of the variance). Because of the non-normal distribution of economic data, we first log transformed the variables and z-transformed scores before creating the composite score of national wealth. Table 2 provides scores for all variables included in this study.

Control Variables

Overall SWB scores were created from three sources. First, we took overall indicators of happiness from the world happiness database (Veenhoven, 2009). Second, Minkov (2009) reported happiness across 1997 to 2000 as the average percentage of participants responding that they are very happy (World Values Survey; Inglehart, 1997). Third, life satisfaction was measured using the World Values Survey data (retrieved June–November 2006 from www.worldvalues survey.com). A principal component analysis revealed a single factorial solution (explaining 75.17% of the variance).

For individualism, we averaged normalized scores for Inglehart's (1997) survival versus well-being dimension across available time points (1981 to 2006), Hofstede's (1980) individualism index, and Schwartz's (1994, 2006) autonomy versus embeddedness score for teachers and students (see Fischer & Boer, 2011). Entering these data into a principal component analysis, a single factor emerged explaining 75.8% of the variance. Loadings ranged from .83 for Hofstede's individualism to .92 for Schwartz's autonomy versus embeddedness student scores. Higher values indicate higher levels of individualism.

Among the control variables, income inequality was measured with the Gini index of household income distribution within a society (UNDP, 2007).

To control for democracy, we used country scores from Vanhanen's (2000, 2002) Index of Democratization for 2000, which is a simple and objective measure of democratic

Table 2. Country-Level Information for All Variables

	Ill-being	Climatic demands	Wealth	SWB	Individualism	Income inequality	Democracy	Disease prevalence
Australia	−0.32	76.00	1.48	1.07	0.98	35.20	35.30	−0.25
Austria	−0.64	83.00	1.51	1.11	1.09	29.10	37.90	−0.77
Belgium	0.08	79.00	1.52	1.07	0.92	33.00	42.70	−1.00
Bosnia	1.98	80.00		−0.32	−0.78	26.20	24.80	0.00
Brazil	−0.05	43.00	0.36	0.58	−0.14	58.00	27.40	0.93
Bulgaria	0.93	78.00	0.32	−1.05	−0.81	29.20	24.10	−0.35
Canada	−0.17	105.00	1.49	1.29	1.10	32.60	24.20	−1.31
Chile	2.51	62.00	0.37	0.58	−0.49	57.10	23.10	−0.45
China	0.21	82.00	−0.47	−0.14	−0.82	44.70	0.00	1.03
Czech Republic	−0.03	91.00	1.06	−0.26	−0.09	25.40	39.30	−0.87
Ethiopia	1.30	54.00	−1.51	−1.00	−1.31	30.00	4.20	0.71
Fiji	−0.74	37.00	0.03		−1.43		0.00	−0.07
Finland	−1.08	98.00	1.46	0.91	0.89	26.90	34.50	−0.75
France	−0.80	75.00	1.50	0.53	1.21	32.70	35.50	−0.46
Germany	−0.37	84.00	1.44	0.22	1.08	28.30	35.50	−0.87
Greece	−0.26	56.00	0.21	0.15	0.26	34.30	35.90	0.08
Hong Kong	1.38	40.00	1.41	−0.39	−0.78	43.40	0.00	0.27
Hungary	−0.75	84.00	0.88	−0.43	0.15	26.90	25.40	−1.00
Iceland	−0.81	73.00	1.55	1.48	1.21		36.10	−1.19
India	0.66	53.00	−0.73	−0.52	−0.52	32.50	16.80	0.94
Indonesia	−0.60	30.00	−0.57	0.07	−1.13	34.30	13.40	0.63
Iran	2.07	75.00	0.21	−0.21	−0.68	43.00	5.20	−0.15
Ireland	−0.33	69.00	1.29	1.29	0.81	34.30	30.10	−0.45
Israel	1.21	59.00	1.28	0.50	0.18	39.20	40.30	0.52
Italy	0.24	59.00	1.44	0.24	0.52	36.00	45.60	0.16
Japan	0.95	52.00	1.47	0.31	0.26	24.90	24.40	0.43
Kiribati	−0.26	29.00	0.34				20.10	
Kuwait	−0.78	55.00	1.48	0.71	−0.42		0.70	−0.34
Lebanon	1.15	50.00	−0.08	−0.49	−0.42		25.90	0.36
Mexico	0.20	49.00	0.54	1.69	−0.38	49.50	20.80	0.28
Morocco	2.18	63.00	−0.27	−0.54	−0.68	39.50	3.90	0.59
Namibia	1.36	56.00	0.22	−0.97	−0.87	74.30	7.60	−0.09
Netherlands	−1.01	77.00	1.57	1.25	1.35	30.90	38.40	−0.87
New Zealand	−0.51	53.00	1.27	1.05	1.33	36.20	34.90	−0.98
Nigeria	−0.10	37.00	−1.55	0.65	−1.28	43.70	9.70	1.16
Norway	−0.70	89.00	1.66	0.91	0.79	25.80	37.90	−0.85
Pakistan	0.64	59.00	−0.86	−0.79	−1.26	30.60	0.00	0.02
Papua New Guinea	−0.11	30.00	−0.71			50.90	29.40	
Poland	0.16	90.00	0.67	0.02	−0.22	34.50	22.30	−0.87
Russia	1.72	101.00	0.51	−0.94	−0.67	39.90	29.30	−0.39
Samoa	−0.19	28.00	0.05				16.90	
Serbia and Montenegro	3.16	83.00		−0.70	−0.38	30.00	20.70	−0.23
Singapore	−1.06	29.00	1.23	0.56	−0.87	42.50	8.50	0.31
Slovakia	0.54	96.00	0.84	−0.46	−0.24	25.80	36.80	−1.00
Solomon Islands	0.21	29.00	−0.80				14.40	
South Africa	1.21	63.00	0.62	0.10	−0.18	57.80	12.40	0.11
South Korea	0.87	79.00	0.86	−0.33	−0.66	31.60	29.10	−0.11
Spain	−0.51	69.00	1.27	0.35	0.52	34.70	31.90	−0.05
Sri Lanka	0.49	30.00	−0.41	−0.31		33.20	23.20	0.64
Sweden	−0.89	89.00	1.49	1.17	1.48	25.00	37.70	−0.98
Switzerland	−0.95	83.00	1.73	1.35	1.51	33.70	40.00	−1.08

(continued)

Table 2. (continued)

	Ill-being	Climatic demands	Wealth	SWB	Individualism	Income inequality	Democracy	Disease prevalence
Taiwan	−0.43	49.00		0.13	−1.26		29.40	0.30
Turkey	0.30	85.00	0.24	−0.02	−0.30	43.60	33.10	0.16
United Arab Emirates	0.55	53.00	1.67	1.15	−0.42		0.00	−0.45
United Kingdom	0.08	67.00	1.47	1.01	1.25	36.00	30.20	−1.01
United States	0.06	79.00	1.71	0.91	0.81	40.80	34.50	−0.89
Vanuatu	−0.52	37.00	−0.44				30.10	
Venezuela	0.22	42.00	0.23	1.24	−0.43	44.10	16.50	0.48

SWB = subjective well-being.

governance. The index is calculated as the product of two subindicators: competition for power (percentage of votes in election or seats in parliament obtained by smaller political parties and independents in the most recent elections) and democratic participation (percentage of population that voted in the most recent elections). Voting in referenda is also included in the participation subindicator.

Pathogen prevalence was calculated by Murray and Schaller (2010) as each country's prevalence of leishmanias, schistosomes, trypanosomes, leprosy, malaria, typhus, filariae, dengue, and tuberculosis. Murray and Schaller (2010) report evidence on validity and reliability of this indicator.

Table 2 reports nation-level indicators for all control variables included in this study.

Results

Hypothesis Testing

We tested our hypothesis about ill-being using moderated regression. First, we entered mean-centered main effect terms for climatic demands and national wealth. The interaction term was entered in the next step. All values reported below are standardized regression weights. The main effect for income per head was significant ($\beta = -.46$, $p < .01$), but the main effect for climatic demands was not significant ($\beta = .26$, $p = .07$). Additively, these two variables explained 17.3% of the variation in ill-being, $F(2, 55) = 5.74$, $p < .01$.

In the next step, the interaction accounted for another 20.8% of the variance, $F(1, 54) = 18.16$, $p < .001$, $\beta = -.46$. As potential outliers can have an undue influence, we examined Cook's distance. The largest yet acceptable value was .49 for the People's Republic of China, followed by Singapore (.15) and Serbia and Montenegro (.11). Nonetheless, to test the influence of these potential outliers on our results, we repeated the analyses without these three cases. The main effect of wealth was significant ($\beta = -.47$, $p < .01$), the effect of climate was not significant ($\beta = .19$, $p = .20$), and most importantly the interaction in the next step remained significant: $\beta = -.53$, $p < .01$. The effect of the interaction appeared to be stronger as the explained variance without these three cases was now 26.8% (accounting for 6% more variance). Therefore, outliers are not a likely explanation of the interaction.

Figure 3 shows the plotted interaction for all countries. Simple slope analysis revealed that in high income societies, climatic demands are negatively related to ill-being ($\beta = -.36$, $p < .05$), whereas in low income countries climatic demands are a strong positive predictor of ill-being ($\beta = .63$, $p < .001$).

In support of our hypothesis, this indicates that in poor countries, demanding climate is a major stressor that leads to greater ill-being of the population. In contrast, in richer countries demanding climate presents a challenge that can be met by converting it into an opportunity for self-expression and engagement through the wealth available to individuals and groups. Another way to look at the same interaction effect is to contrast demanding and temperate climate in terms of wealth effects. As expected, in temperate climates, income does not make a difference to average levels of ill-being. In highly demanding climates in contrast, income makes a significant difference. In rich societies, people have the resources to counter the negative effects of a demanding climate, whereas in poor countries people are at the mercy of climate, which then negatively affects their SWB (leading to lower general health, as well as more burnout, anxiety and depression).

Robustness of the Effect: Bootstrapping

We employed bootstrapping to explore robustness because we are relying on a relatively small sample of countries, which may lead to biased and instable results, particularly when examining complex models involving interactions. Furthermore, it is an ideal technique to rule out outliers as potential explanations. We ran a bootstrap analysis with 1,000 random samples with replacement in Mplus 6.0 (Muthén & Muthén, 1998–2010). The bootstrapped 95% and 99% confidence intervals for the interaction ranged from –.87 to –.28 and from –.96 to –.19, respectively.

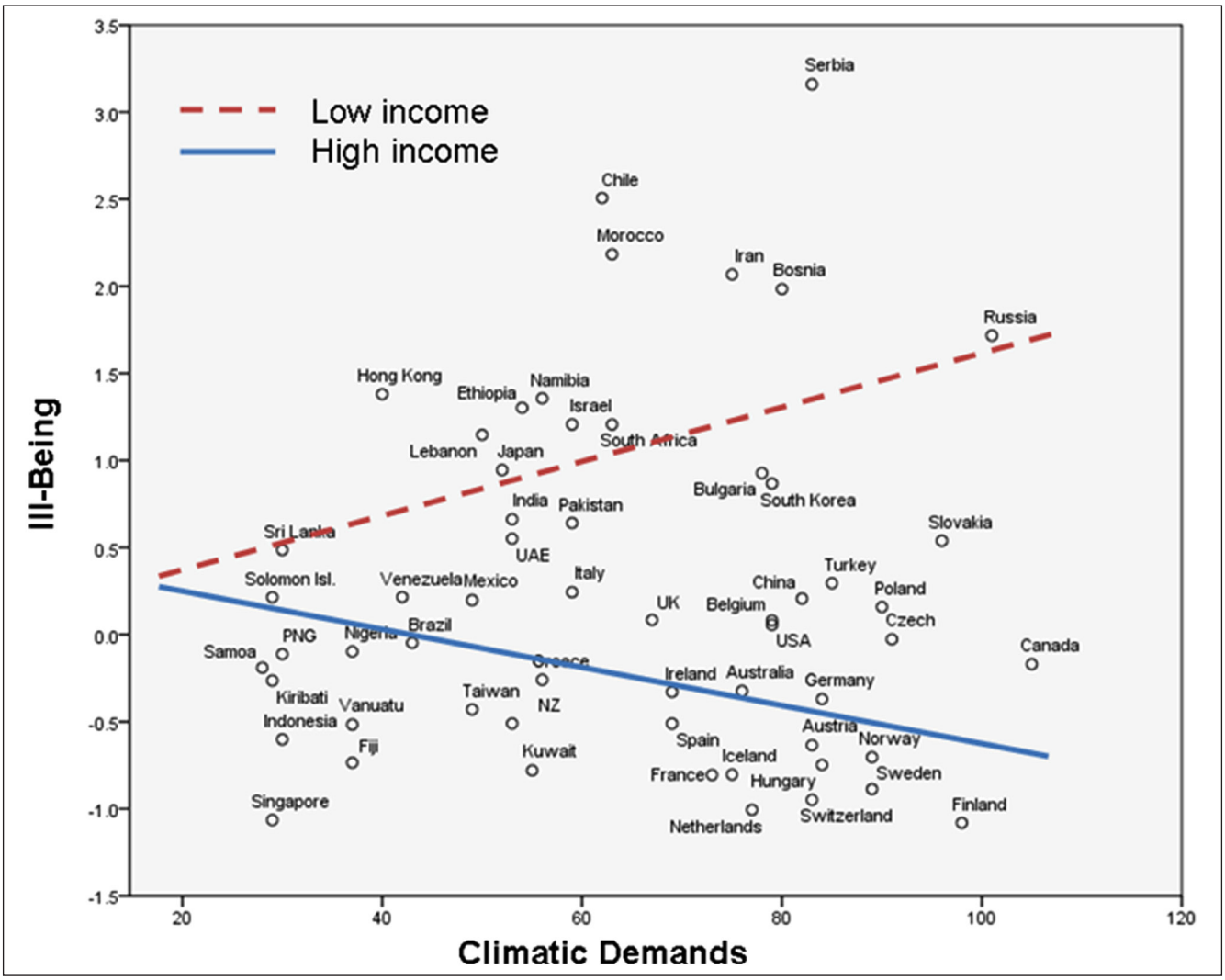

Figure 3. Interaction between climatic demands and national wealth, predicting ill-being

Because the confidence intervals did not include zero, the effect was significant and robust. Hence, there is no indication that our results are from spurious relationships or outliers.

Direction of Effect: Reversed Effect

It may be possible that the effect is running in the opposite causal direction, that is, mentally well-adjusted and happy individuals can deal better with climatic demands, work more effectively, and thereby produce a higher income. We tested this inverse relationship in three ways. First, we used the combined and log-transformed income measure as a dependent variable and ill-being, climatic demands, and the interaction between the two as independent variables. The effects of climate ($\beta = .48$, $p < .01$) and ill-being ($\beta = -.37$, $p < .01$) were significant, but not the interaction: $\beta = -.13$, $p = .40$, $\Delta R^2 = .009$. Therefore, the inverse relationship does not hold for the whole time span. Next, we tested the reversed causal direction of the time component more directly. The ill-being indicators were derived from published studies, with the majority being published in the mid-1990s. Therefore, we tested whether the interaction between ill-being and climate is significant for wealth before most ill-being data were available (1975) as well as after (2007; using indicators from UNDP, 2009). In both analyses, climate had a significant effect (1975: $\beta = .33$, $p < .05$; 2007: $\beta = .44$, $p < .01$), but ill-being had an effect only for wealth in 2007 ($\beta = -.45$, $p < .01$) and not for wealth in 1975 ($\beta = -.27$, $p = .07$). Most importantly, the interaction was not significant in either analysis (1975: $\beta = -.18$, $p = .38$; 2007: $\beta = -.21$, $p = .15$, explained variance below 2% in both analyses). Therefore, the reversed relationship did not hold in our data, and this causal alternative relationship can be rejected.

Top-Down Versus Bottom-Up Processes

We next tested whether SWB influences ill-being or vice versa. To test these mediation path models, we again used

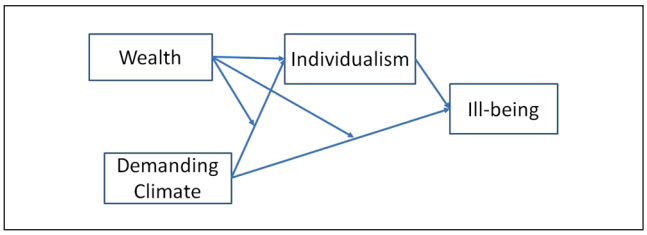

Figure 4. Final path model linking climato-economic variables to ill-being and individualism

Mplus 6.0 (Muthén & Muthén, 1998–2010) with observed and centered indicators and maximum-likelihood estimation. The first model tested SWB as a mediator between the joint effects of climate and wealth on ill-being. The main effects of climate (stand coeff = –.32) and wealth (stand coeff = .59) and the interaction effect (stand coeff = .40) on SWB were significant (all *p*s < .05, explained variance 49.7%). This finding confirms and extends previous research, as we report an analysis on a broader SWB variable than Van de Vliert (2009). SWB in turn was also significantly and negatively related to ill-being (stand coeff = –.59, $p < .01$, explained variance 35.4%). Model fit was $\chi^2(3) = 8.52$, $p = .03$, comparative fit index (CFI) = .91, standardized root mean square residual (SRMR) = .05.

In contrast, the model in which ill-being was the mediator did not fit as well: $\chi^2(3) = 19.59$, $p < .001$, CFI = .74, SRMR = .08. The effects of climate (stand coeff = .23), wealth (stand coeff = –.39), and the interaction (stand coeff = –.46, all $p < .05$, explained variance 34.7%) on ill-being were significant. The effect of ill-being on SWB in turn was significant but explained less variance (stand coeff = –.59, explained variance 28.1%). Therefore, in terms of model fit, the effect of climato-economic variables on ill-being was better explained by SWB than vice versa. This model with SWB as a mediator also resulted in more explained variance in the final variable ($\Delta R^2 = 7.3\%$). It appears that SWB is a statistically more effective mediator of the effect of climate and wealth on ill-being than the other way around. Demanding climates with insufficient resources affect overall levels of well-being, which then filter through to specific indicators of ill-being (i.e., anxiety, depression, exhaustion, lowered mental health). This suggests that current research on SWB captures an important variable of well-being of citizens, which in turn may explain psychosocial conditions of the average individual in a population.

Modeling the Ecological Process: Individualism as Mediator

Next, we tested whether climato-economic effects on ill-being can be explained through known associations of climate and wealth with individualism.

To test this mediated moderation process (see Figure 2), we used similar procedures as above. Individualism was regressed on wealth, climate, and the interaction between wealth and climate, and ill-being in turn was regressed on individualism. Thus, individualism is tested as a potential mediator of the joint effects of climate and wealth on ill-being. Replicating earlier work with a new and broader indicator of individualism, climate (stand coeff = .22, $p < .05$), wealth (stand coeff = .58, $p < .01$), and the interaction (stand coeff = .36, $p < .05$) all predicted individualism (explained variance = 68.1%). Individualism in turn predicted ill-being (stand coeff = –.45, $p < .05$, $\Delta R^2 = .199$). However, the model did not fit the data particularly well: $\chi^2(3) = 17.07$, $p < .001$, CFI = .83, SRMR = .09. Based on the modification indices, freeing up the direct paths from climate to ill-being as well as adding a direct path from the interaction to ill-being provided substantively better model fit: $\chi^2(1) = 2.43$, $p = .12$, CFI = .98, SRMR = .02. The direct effect of climate on ill-being was significant (stand coeff = .28, $p < .05$), as was the interaction between climate and wealth (stand coeff = –.33, $p < .01$). When added, the direct path of wealth was not significant ($p = .18$), but the interactive effect remained significant ($p < .01$). The explained variance in ill-being was 40.0% and in individualism 69.1% (see Figure 4 for the final model). This implies that (a) the direct effects of wealth on SWB observed in previous studies (Diener et al., 1995; Diener et al., 2010; Stevenson & Wolfers, 2008) may be mediated through individualism, (b) the interactive effect of climate and wealth on ill-being is robust and, at least in our data, cannot be challenged by individualism explanations, and (c) the interactive effect of wealth and climate on ill-being is not mediated by individualism (the climato-economic effects have a direct and unmediated effect on ill-being).

Robustness of the Effect: Controlling for Known Correlates

First, inequality entered in the first step accounted for 16.9% of the variance: $F(1, 44) = 8.96$, $p < .01$. Greater inequality is associated with greater ill-being ($\beta = .41$, $p < .01$). Climatic demands and national wealth in the next step predicted another 12.0% of explained variance: $F(2, 42) = 3.55$, $p < .05$. The effect of wealth was still significant ($\beta = –.39$, $p < .05$), but not the effect of climate ($\beta = .23$, *ns*). The interaction in the final step added another 14.5% of explained variance: $F(1, 41) = 10.48$, $p < .01$.

Next, democracy accounted for 12.6% of the variance: $F(1, 53) = 7.61$, $p < .01$. Greater democracy in 2000 was associated with less ill-being ($\beta = –.34$, $p < .01$). Climatic demands and national wealth predicted further 8.0% of the variance in our dependent variable, but this effect was only marginally significant: $F(2, 51) = 2.65$, $p = .08$. More importantly, the climato-economic interaction added another 15.1% of explained variance: $F(1, 50) = 11.81$, $p < .01$. Thus,

controlling for democracy does not affect the joint impact of climatic demands and national wealth on reported ill-being.

Finally, when controlling for the prevalence of diseases, greater spread of these nine diseases accounted for 14.0% of the variability in ill-being: $F(1, 48) = 7.81$, $p < .01$. The main effects of climate and wealth in the next step did not predict any significant amount of variance: $F(2, 46) = 2.13$, *ns*, $\Delta R^2 = .073$. However, the interaction still accounted for further 15.2% of the variance: $F(1, 45) = 10.81$, $p < .01$.

In summary, the interaction remained significant after controlling for these other variables that are either known to influence well-being or are closely related to ill-being. Controlling for any of these variables in additional bootstrap analyses (details available from first author) did not affect the significance of the interaction effect of climato-economic liveability on ill-being. More importantly, the variance accounted for after controlling for these variables was in the range of 14% to 15%. Therefore, the mechanism that we identified is nontrivial and can explain a substantive amount of variation in ill-being over and above known predictors of well-being.

Discussion

Climatic demands and local wealth jointly affect psychological health of humans. Wealth, individualism, democratic institutions, and lack of pathogenic diseases all have a reliable and important impact on our mental health, but the environmental context in the background adds another important element to our understanding of positive and negative manifestations of well-being. Climatic demands provide potential threats to humans, and the question of how these demands affect well-being and ill-being depends on how well humans are positioned to cope with them. If living in a climatically demanding environment, having resources to meet these demands provides stimulating challenges and opportunities for personal growth, leading to some of the lowest levels of ill-being. In contrast, if individuals are faced with climatic demands without adequate resources to meet the demands, this increases levels of stress manifested in experiences of health problems, burnout, anxiety, and depression.

These results provide novel insights, pointing to more distant and heretofore hidden environmental factors influencing psychological health. Climate has been linked to happiness (Rehdanz & Maddison, 2005) as well as other variables that have an impact on happiness (such as occurrence of civil war and violence; e.g., Tol & Wagner, 2010; Van de Vliert, Schwartz, Huismans, Hofstede, & Daan, 1999; Zhang, Brecke, Lee, He, & Zhang, 2007). However, instead of a simplistic picture of climate affecting social variables, our analysis paints a more complex, and presumably more accurate, picture. Furthermore, our analysis suggests that distal ecological effects influence ill-being via general evaluations of life satisfaction and SWB. Humans can cope with harsh winters and summers and with climatic changes if they have the resources available to them to meet climatic demands. The mediation effect suggests that these ecological variables have a first impact on overall evaluations of one's life, which in turn then influences levels of stress, anxiety, and psychological ill-health. Our analysis paints an interactive picture of ill-being, opening the avenues for general interventions. For example, providing economic resources or means to actively require them (e.g., micro financing) is likely to be particularly effective in demanding climates where individuals do not have the means to cope with the demands. In contrast, in more temperate climates, the availability of economic resources would have little effect on the well-being of the population overall. Here, one option would be to investigate interventions or programs that provide more stimulating environments and create challenges for positive growth.

The strength of our analysis lies in the fact that we used data based on well-validated and psychometrically sound multi-item inventories and objective yet unobtrusive climate and wealth data to provide new insights in the determinants of levels of well-being. At the same time, our measures and empirical tests are not without limitations. For example, we have no indicators of the actual climatic demands faced by individuals: Survival needs for thermal comfort, nutrition, and health were not measured and analyzed. As a consequence, our climato-economic hypotheses about population-level ill-being were successfully tested, but not their ultimate theoretical rationale. The ability to account for some substantive variation in well-being levels over and above known correlates of well-being comes with the weakness that the indicators were based on ill-matched samples of nations, across various time points (ranging from the late 1960s to the early 2000s) and samples of specific populations (often student, white-collar, or general population samples) reported in previous research. However, our bootstrap analyses, reversed causal models, and attempts to disconfirm the findings show that these patterns are not the result of fluctuations in our data or other variables that may drive these relationships. In effect, the persistence of the findings shows that climate and wealth have such a strong effect together that the patterns emerge even in ill-matched samples across various populations, regions, and time spans.

The results of our analysis have a number of theoretical implications. We demonstrated that ecological variables in the background can affect psychological variables. Much current research at the society level attempts to explain psychological or social variables using value or belief data that are thought to reflect basic cultural tendencies. Many of these indicators are also derived from survey measures of more or less well-matched samples in each nation. Our analysis demonstrates that both cultural dimensions such as individualism and psychological or social criterion variables such as ill-being can be linked back to the ecological conditions in which participants are located. For example, our

process model linking ecological conditions to ill-being via individualism showed that both sets of variables were equally influenced by the wealth and the interaction between wealth and climate. Only the effect of wealth on ill-being was mediated by individualism. This demonstrates that focusing on psychological variables for explaining cultural differences in other psychological variables while neglecting the background variables influencing both sets of variables may lead to blurred pictures of cultural effects. Observed relationships among values, beliefs, and other psychological indicators may equally be influenced by unmeasured third variables in the background, an issue that is well known in applications of regression analyses at the individual level (Cohen, Cohen, West, & Aiken, 2003).

At the same time, our analysis also shows that accounting for more distal variables, process mechanisms can be explored more systematically. We could show that a model linking climato-economic process to ill-being via previously researched SWB fitted the data quite well. When including more distal variables, the order of more proximal variables can be examined more closely. One of the problems of path analysis based on correlational data is often the causal ordering in any model tested. By including ecological variables researchers can add predictive power to their analyses as relationships between proximal psychological variables can be examined through their association with these external ecological variables (see Iacobucci, Saldanha, & Deng, 2007). Adding ecological variables to models can help developing better understandings of cultural processes.

What are the practical implications? Our pattern of findings may shed novel light also on two huge threats humanity faces today: global warming and local poverty. There is mounting evidence that climatic changes and the stress induced by these changes is associated with population decline and civil war, both over larger historical periods (Tol & Wagner, 2010; Zhang et al., 2007) as well as during our century (Burke, Miguel, Satyanath, Dykema, & Lobell, 2009). Previous economic analyses suggest that expected climatic changes will benefit a few countries in higher latitudes but will have negative impacts on countries situated in warmer regions (Rehdanz & Maddison, 2005). Assuming that Figure 3 is a valid representation of the relationships between threatening climato-economic habitats and well-being and reflects underlying causality (from climate to well-being moderated by wealth) rather than simultaneity, a plausible increase of about 2°C to 5°C of global warming may be expected to increase ill-being in poorer countries but to decrease it in richer countries. Such a modest amount of global warming in conjunction with economic growth may be expected to reduce burnout, anxiety, depression, and other manifestations of climato-economic-induced stress. International bodies such as the World Health Organization and the UNDP can use these new insights to especially promote the physical and mental health of people carving out a living in particularly stressful climato-economic environments.

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